

QUALITY OF GROUND WATER AT SELECTED SITES IN THE UPPER MAHONING CREEK BASIN, PENNSYLVANIA



- Fifty wells or springs were sampled within the 207 square mile upper Mahoning Creek Basin.
- No VOC, triazine herbicide, or nitrate concentration exceeded water-quality standards.
- Concentrations of manganese, iron, lead, radon, pH, hardness, and bacteria were most commonly found in exceedance of water-quality standards.
- Eighty-six percent of the radon exceedances were in water from the Glenshaw Formation.
- Seventy-four percent of the samples contained coliform bacteria.

WHY STUDY THE UPPER MAHONING CREEK BASIN?

The ground-water quality of the upper Mahoning Creek Basin is largely unknown. Human activities in the basin have altered much of the landscape. The presence of coal mining, oil and gas exploration, agriculture, on-lot septic systems, and commercial development within the basin can introduce contaminants altering the natural chemistry of the ground water. Data collected to document current

ground-water quality also can serve as a baseline for comparison of any future water-quality changes by continuing human activities.

This report presents the results of a synoptic ground-water-quality sampling in the upper Mahoning Creek Basin. Present ground-water quality in the basin is characterized in relation to published standards, local land-use activities, and other areas with similar natural characteristics.

WHAT IS THE DESCRIPTION OF THE STUDY AREA?

The basin occupies about 207 square miles upstream of the confluence of Little Mahoning Creek and Mahoning Creek in Jefferson, Indiana, and Clearfield Counties in western Pennsylvania (fig. 1). The basin lies within the Allegheny Plateau Section of the Appalachian Plateaus Physiographic Province (Fenneman, 1938). Mahoning Creek flows to the west across the plateau to its confluence with the Allegheny River about 60 miles north of Pittsburgh.

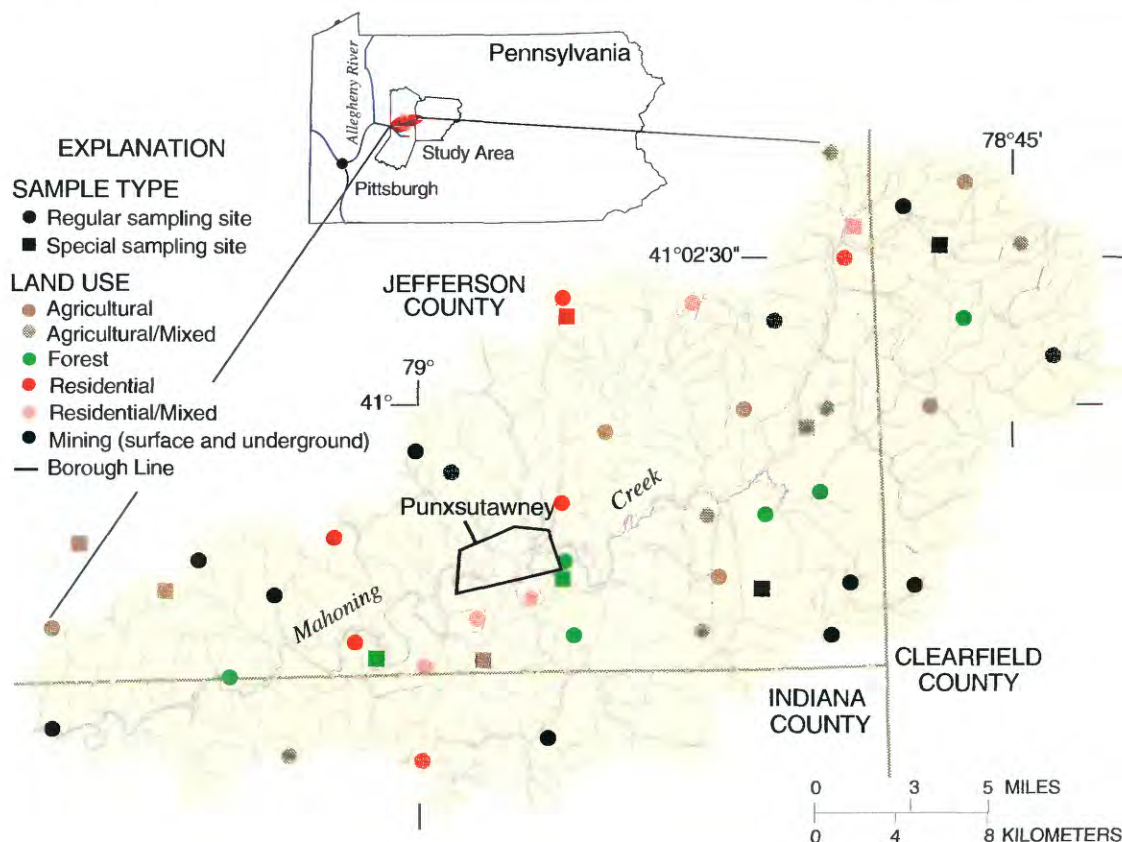


Figure 1. Location of study area, location and type of sampling sites, and land use near sampling site.

Major land uses in the basin include agriculture, forest, mining, and residential/commercial development. Concentrated areas of oil and gas drilling also exist. Land-use data compiled from 1972-75 indicate that about 32 percent of the basin was agricultural, 62 percent was forested, and 3 percent was surface mined. By 1995, surface mining increased to about 6 percent and forested areas declined to about 58 percent of the basin. Although difficult to accurately quantify, a large number of underground mines also are present.

The basin is underlain by rocks of the Conemaugh, Allegheny, and Pottsville Groups, all of Pennsylvanian age. The Conemaugh Group is further divided into the Casselman Formation and the Glenshaw Formation. All rock groups are composed primarily of flat layers of sandstones, siltstones, and shales that contain thin beds of limestone and coal. The coal has been extensively mined by surface and underground workings. Ground water is present in and moves through these consolidated rocks mostly within fractures. Movement is from upland recharge areas to points of discharge at local springs, seeps, and streams. Along the flow paths, the chemical quality of the ground water is affected by many factors, including human activities, rock types, biota, and soil characteristics.

HOW WAS THE STUDY CONDUCTED?

The U.S. Geological Survey (USGS), in cooperation with the Jefferson County Department of Development, collected water-quality samples at 46 domestic wells and 3 springs in the basin from August 24 to September 7, 1995. Additionally, one site outside of the basin was sampled. The study was conducted in three phases:

- (1) identifying sites available for sampling,
- (2) sampling the sites, and
- (3) compiling and analyzing the data.

Fifty sites were identified for sampling (fig. 1) to ensure that ground water throughout the geographic extent of the basin is represented and that water from all major land uses and rock types is included (table 1). The study area was divided into 40 blocks of about 6 square miles each, and a domestic well within each grid block was selected for sampling. In addition, 10 wells or springs (identified as "special sites" in fig. 1) were selected for sampling in areas of known water-quality problems. At each well where permission to collect a water sample was obtained, site characteristics (including land use) were recorded and plumbing was inspected to insure that a raw water sample could be collected before passing through any treatment or filtering devices.

Table 1. Distribution of sampled sites by land use and rock type

Land use	
Category	Number of sites
Forest	8
Agricultural	¹ 9
Agricultural/mixed	7
Residential	7
Residential/mixed	5
Mining	14
Total	¹ 50
Major rock type	
Group (formation)	Number of sites
Conemaugh	
(Casselmann)	11
(Glenshaw)	21
Allegheny	¹ 17
Pottsville	1
Total	¹ 50

¹ Includes site outside of basin.

Immediately before collecting a water sample, each well was purged until temperature, dissolved oxygen, specific conductance, and pH stabilized. Raw water samples were collected in the homeowner's plumbing system nearest to the well. All samples were analyzed by the USGS except bacteria, which was analyzed at the Pennsylvania Department of Environmental Protection.

The results of chemical and biological analyses of water samples and physical characteristics for 50 sites were compiled and entered in the USGS database and the results were delivered to participating homeowners. Data analyses include descriptive statistics of the chemical and biological data. The statistics are used to help describe the water-quality conditions in the basin.

WHAT WAS SAMPLED AND WHY?

The constituents sampled in this study were selected to (1) represent naturally occurring minerals in the rock and soil, (2) represent the contaminants commonly associated with particular land uses, and (3) characterize water quality in relation to published drinking water-quality standards or guidelines. The 72 constituents sampled in this study can be grouped into the following 8 categories: nutrients, major ions, trace elements, triazine herbicides, volatile organic compounds (VOC's), radon, total coliform bacteria, and field characteristics. Samples were collected at all 50 sites for analysis of all constituents except for VOC's (30 sampled sites,

including the 10 special sites) and total coliform bacteria (23 sampled sites). Additionally, temperature, pH, specific conductance, dissolved oxygen, and alkalinity were measured in the field at all 50 sites. In this report, 56 of the 72 constituents analyzed for will be discussed. The remaining 16 constituents do not have published water-quality guidelines. All data collected will be published in the USGS annual report.

In forested areas, potential contaminants are usually airborne and deposited atmospherically, primarily with precipitation. Because forested areas are generally unaffected by local human activities, ground-water data from forested areas sometimes are used to represent "natural" conditions. The "natural" ground-water concentrations can be compared to areas likely to have been influenced by human activity. In agricultural areas, potential contaminants include fertilizers (manure and commercial) and herbicides. The elements nitrogen, phosphorus, and potassium (nutrients) are the basic components in most fertilizers. Elevated nutrient concentrations in ground water generally are caused by human activities. For crops such as corn, triazine herbicides are usually applied as a preemergent weed control. In residential areas, potential contaminants include household solvents, detergents, septic tank effluent (nitrate, chloride, and bacteria), and fertilizer and pesticides from lawn care. In commercial and mining areas, potential contaminants include metals and VOC's. Most solvents, detergents, and VOC's are manufactured, therefore, their presence in ground water is indicative of human activity.

Water quality may be characterized by physical properties and by the concentration of dissolved and suspended constituents. One measure of water quality is the set of guidelines established by the U.S. Environmental Protection Agency (USEPA) (1986, 1991) for public drinking-water supplies. For domestic drinking-water supplies, USEPA regulations are not enforceable but may be used as guidelines to assess water quality. The USEPA has established two levels of concern for some constituents in drinking water, maximum contaminant levels (MCL's) and secondary maximum contaminant levels (SMCL's). MCL's generally are established because elevated concentrations of these constituents may cause adverse health effects. SMCL's generally are established for aesthetic reasons such as staining of clothes and water fixtures and undesirable tastes or odors.

WHAT WAS FOUND IN THE GROUND WATER?

Of the 50 sampled sites, 38 sites had at least 1 constituent concentration that exceeded 1 MCL or SMCL. Coliform bacteria and iron and manganese concentrations most often exceeded the guidelines. No VOC's, nutrients, or triazine herbicide concentrations exceeded any guidelines.

Of the 56 constituents analyzed and discussed, 28 constituents were found in detectable concentrations (fig. 2). Three of the 26 VOC's analyzed were measured above the detection limit, however, none were measured above the MCL or SMCL. Toluene, a solvent generally obtained from coal tar, was detected at two sites, one mining site and one "special site" located on a flood plain. Ammonia was detected at 21 sites; the highest concentration occurred at a residential site. Sixteen of the nineteen metals and trace elements analyzed were detected. All are naturally present in the rocks and soils in the basin. The widespread detection of barium, iron, lithium, manganese, strontium, and zinc indicates natural sources not associated with a specific land use. The detection of cobalt and silver probably also represents natural background concentrations. Two trace metals, arsenic and beryllium, were detected at sites associated with mining activities. The highest copper concentrations were detected in samples that were acidic (low pH). The acidic water may have leached copper from plumbing systems. Zinc was detected at 34 sites, including the 8 sites

where copper was detected, indicating zinc may also be leaching from plumbing systems.

Additionally, water was considered "hard" (greater than 120 milligrams per liter as calcium carbonate) at 29 sites. Hard water usually indicates high concentrations of dissolved solids and major ions, such as chloride and sulfate.

Of the 28 constituents detected, 12 were found in concentrations exceeding 1 MCL or SMCL (table 2). Although exceedances [value greater (or less for pH) than USEPA guidelines] occurred in all land uses and rock types, 41 percent of the exceedances occurred at sites associated with mining activities. Maximum exceedance values for all 12 constituents, except bacteria, cadmium, and radon, were also associated with mining activities. In mining areas where large volumes of rock and soil have been disturbed, the oxidation of pyrite (a common iron ore) produces acidic water. This resultant acidic water is available to chemically react with and dissolve many natural elements. One-half of the pH exceedances were in mining areas. At all these sites except one, iron and manganese exceeded the SMCL. Lead concentrations generally were related to leaching of domestic plumbing by acidic water (six of nine sites) regardless of a specific land use. Chloride, sulfate, and three of four dissolved solids exceedances occurred in the areas associated with mining activities.

Proposed radon standards were exceeded in water samples for 28 percent of the sites. Radon is a naturally occurring radioactive gas produced by the decay of

Table 2. Constituents that exceeded USEPA guidelines (U.S. Environmental Protection Agency, 1996)

[MCL, maximum contaminant level; SMCL, secondary maximum contaminant level; µg/L, micrograms per liter or parts per billion; mg/L, milligrams per liter or parts per million; pCi/L picocuries per liter; <, less than; >, greater than; TNTC, to numerous too count; NA, not applicable]

Constituent	Number of detects	Type of guideline	USEPA guideline	Percentage of sites with exceedances	Maximum exceedence value
pH	NA	SMCL	< 6.5 or > 8.5	20	3.3
Chloride	50	SMCL	250 mg/L	2	300
Sulfate	50	SMCL	250 mg/L	4	440
Dissolved solids	50	SMCL	500 mg/L	10	677
Aluminum	13	SMCL	50 µg/L	12	5,500
Cadmium	10	MCL	5 µg/L	2	7
Iron	45	SMCL	300 µg/L	30	60,000
Lead	13	MCL	15 µg/L	18	50
Manganese	48	SMCL	50 µg/L	54	5,100
Nickel	6	MCL	100 µg/L	2	100
Radon	50	MCL	¹ 300 pCi/L	28	1,400
Coliform bacteria	17	MCL	1 colony	74	TNTC

¹ Proposed MCL.

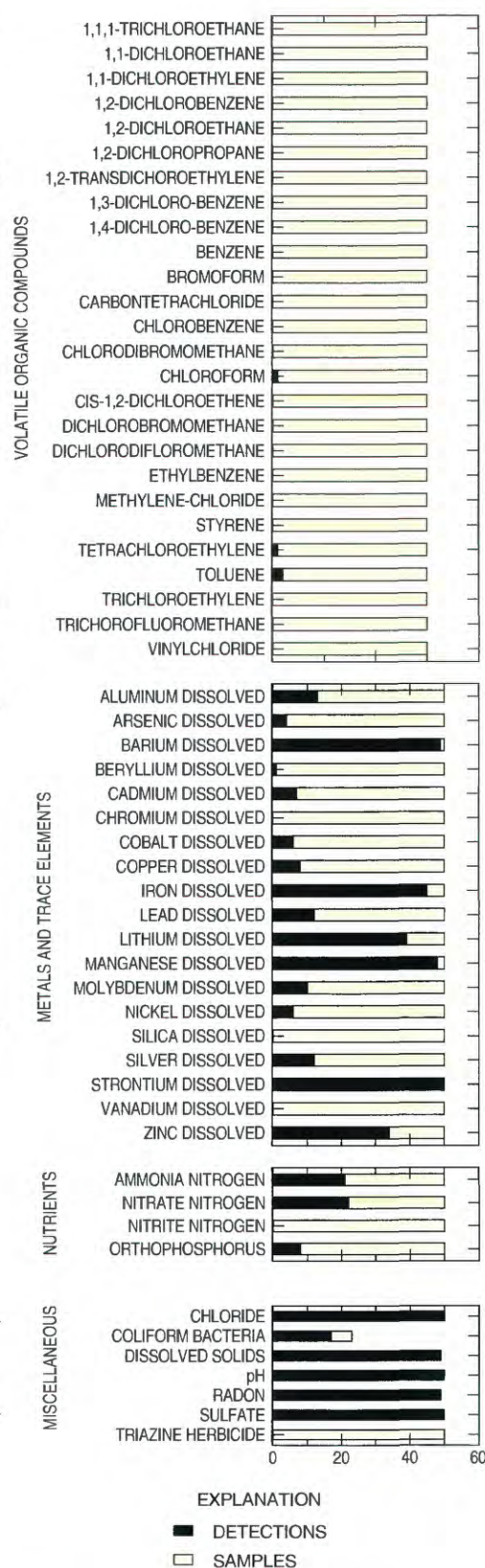


Figure 2. Detected constituents.

the element radium. Natural factors control the occurrence of uranium and the formation and movement of radon in soils and water. Radon exceedances were associated more with rock type than land use; 18 of the 21 exceedances were in the Glenshaw Formation.

The MCL for coliform bacteria was exceeded at 74 percent of the sites. This percentage is higher than other similar studies in Pennsylvania where coliform bacteria was exceeded in about 42 percent of the sampled wells (Sharpe and others, 1985). Coliform usually is an indicator of the presence of human or animal contamination. High bacteria counts generally indicate a contaminated water source. Sources of contamination could include improperly functioning septic systems, improperly sealed wells, and runoff from barnyards.

HOW DO THE RESULTS COMPARE TO OTHER SIMILAR AQUIFERS?

Selected constituents from this study were compared to constituents collected from 1925 to 1965 (U.S. Geological Survey, 1986) in Pennsylvania (fig. 3). Generally, the water quality in the basin is not significantly different from water quality in similar shale and sandstone aquifers located throughout Pennsylvania. The range in concentrations of chloride, hardness, and dissolved solids varies little between the basin and statewide samples. The range in nitrate concentrations was less in the basin than in the statewide samples, probably because of a lack of intensive agricultural activity. Iron concentrations show the greatest variability, probably because of both the high natural concentrations in the rock and the presence of mining activities.

SUMMARY

In summary, 47 wells and 3 springs were selected for a synoptic sampling to characterize the ground-water quality in the upper Mahoning Creek Basin. Land use in the basin includes forest, agriculture, and surface mining. Rock types include the Conemaugh, Allegheny, and Pottsville Groups. Analysis of 56 constituents included nutrients, major ions, trace elements, triazine herbicides, volatile organic compounds (VOC's), radon, total coliform bacteria and field characteristics. No VOC's, triazine herbicide, or nitrate concentrations exceeded the water-quality guidelines for drinking water. Twelve sites did not exceed any water-quality guidelines for drinking water. Concentrations of iron, lead, manganese, pH, coliform bacteria, and radon were commonly detected in excess of water-quality guidelines.

Few patterns emerged from the sampling. Many of the exceedances were found in samples from both natural and human-influenced areas. Forty-one percent of the exceedances were associated with mining activities. Maximum exceedance values for 9 of 12 constituents were also associated with mining activities. Eighty-six percent of the radon exceedances were in water associated with rock of the Glenshaw Formation.

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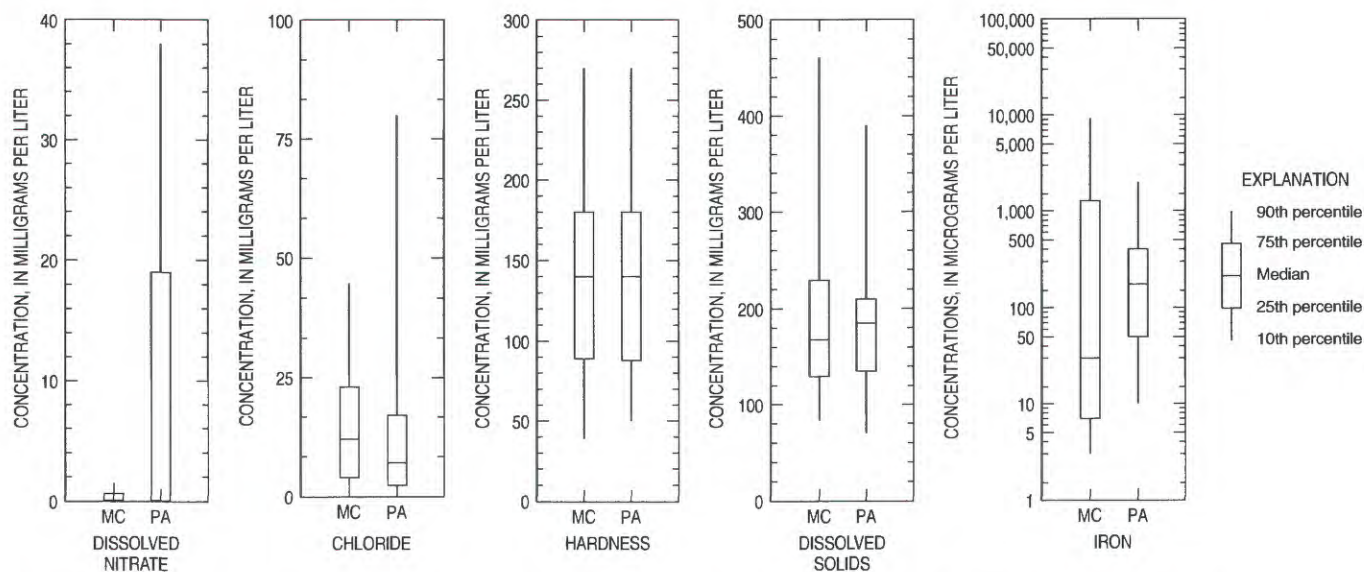


Figure 3. Comparisons between ground water from the Upper Mahoning Creek (MC) Basin and similar aquifers in Pennsylvania (PA).